UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

FEB 3 2017

Mr. Ron Milligan
Operations Manager, Central Valley Project
U.S. Bureau of Reclamation
3310 El Camino Avenue, Suite 300
Sacramento, California 95821

Dear Mr. Milligan:

This letter provides the U.S. Bureau of Reclamation (Reclamation) with the estimated number of juvenile Sacramento River winter-run Chinook salmon (winter-run, *Oncorhynchus tshawytscha*) expected to enter the Sacramento-San Joaquin Delta (Delta) during water year (WY) 2017. This juvenile production estimate, or JPE, is calculated by NOAA's National Marine Fisheries Service (NMFS) pursuant to the June 4, 2009, biological opinion on the long-term operations of the Central Valley Project (CVP) and the State Water Project (SWP, CVP/SWP operations Opinion). The JPE is calculated annually and is used to determine the authorized level of incidental take for winter-run, under section 7 of the Endangered Species Act (ESA), while operating the CVP/SWP Delta pumping facilities in a given water year (NMFS 2009).

Due to their imperiled status, NMFS included winter-run as one of eight species highlighted in our agency's "Species in the Spotlight" initiative[1]. This initiative is an effort to focus attention and resources to managing NMFS's eight most critically endangered species with the goal of reversing their trajectories towards extinction.

One of the most significant impacts to winter-run in recent time is California's current extended drought. In 2016, for the third year in a row, we collectively planned a summer and fall release schedule for Shasta Reservoir to meet the needs of all users, including fish and wildlife, given the limits the drought placed on available supplies. With significant partnership and commitment from both our Federal and State agency and our water and irrigation district partners, we were able to successfully execute the 2016 temperature management plan, with Reclamation able to meet the temperature compliance point of 56.0°F daily average temperature at Balls Ferry this summer for the first time since 2012. In addition, since overall conditions were better than forecasted, Reclamation was successful for part of the temperature management season in meeting a temperature metric of 55.0°F 7-day average of the daily maximum temperatures to the downstream most redd, which was approximately 13 miles downstream of Keswick Dam.

We are happy to report that the impacts of this success include temperature-dependent mortality estimates of only 2% of the winter-run population in brood year 2016, significantly below the approximately 77% and 85% temperature dependent mortality exerted on the populations in

[1] http://www.nmfs.noaa.gov/stories/2015/09/spotlight_chinook_salmon.html

brood years 2014 and 2015, respectively. This success, combined with a Shasta Reservoir end of September storage of 2.8 million acre feet--substantially higher than in 2014 [1.2 million acre-feet (maf)] and 2015 (1.6 maf)--sets us in a better starting point for operations in WY 2017.

As a result, the winter-run JPE for brood year (BY) 2016 is 166,189 natural-origin juvenile winter-run entering the Delta during WY 2017. This JPE led to a calculation of an incidental take level of 1,662 natural (non-clipped) winter-run.

The incidental take level of hatchery-produced (clipped) winter-run for WY 2017 is 582, which represents a lower level of incidental take than was authorized in the previous two years. This decrease in the incidental take level of hatchery winter-run is reflective of the Livingston Stone National Fish Hatchery (LSNFH) hatchery production level (*i.e.*, 141,922 winter-run juveniles released). Hatchery production at LSNFH was increased in 2014 and 2015 to ~600,000 and ~420,000 fish, respectively, released to compensate for expected losses in natural production due to drought conditions.

The process for developing the JPE was the similar to what was done in 2015. A technical team from the Interagency Ecological Program, the Winter-run Project Work Team (WRPWT), met throughout the year and provided recommendations in a letter to NMFS (enclosure 2). The method used to calculate the 2016 JPE is derived from the number of juveniles passing Red Bluff Diversion Dam estimated by the U.S. Fish and Wildlife Service (USFWS) and is the same method as was used in 2015, except for a change in calculation of fecundity. The fecundity rate was lower in this year's calculation as a result of a larger than average return of 2-year old, smaller, females (see USFWS Memo within enclosure 2).

Examination of 2016 Data; JPE Model Investigation

The CVP/SWP operations Opinion defines the JPE as juvenile survival to the beginning of the Delta (*i.e.,* Tower Bridge in Sacramento), but not through the Delta. The calculation of the winter-run JPE for BY 2016 begins with estimates of winter-run adult escapement for 2016, which are derived from carcass surveys conducted in the upper Sacramento River by the California Department of Fish and Wildlife (CDFW). This escapement information was provided to NMFS via a December 23, 2016, letter (enclosure 1). The CDFW estimate for total winter-run escapement in 2016 was **1,546 spawners** (90% confidence interval: 329 to 2,763)[2]. Of this total number of spawners, 137 were collected at the Keswick trap for Livingston Stone National Fish Hatchery (LSNFH) broodstock, leaving an estimated 1,409 to spawn naturally in-river.

The number of adult spawners in 2016 (1,546) decreased considerably from 2015 (3,439), and was lower than the 10-year average (*i.e.,* 2,909) for 2007–2016 (figure 1). The cohort replacement rate (CRR), which is a measure of the population's growth rate, turned negative (0.25 < 1.0) in 2016, for the first time since 2012 (figure 2), indicating an overall population decline. However, despite the fewer adults, fewer females, and lower fecundity in 2016, the number of juvenile winter-run produced was higher than in both 2014 and 2015 due to increased

[2] The methodology used by CDFW (*i.e.*, Cormack-Jolly-Seber Model) to estimate escapement is the same model that has been used since 2012.

survival during the egg-to-fry life stage, likely as a result of successful execution of the 2016 temperature management plan (as described above).

Figure 1. Winter-run spawning escapement 2006-2016 (CDFW 2016 and enclosure 1).

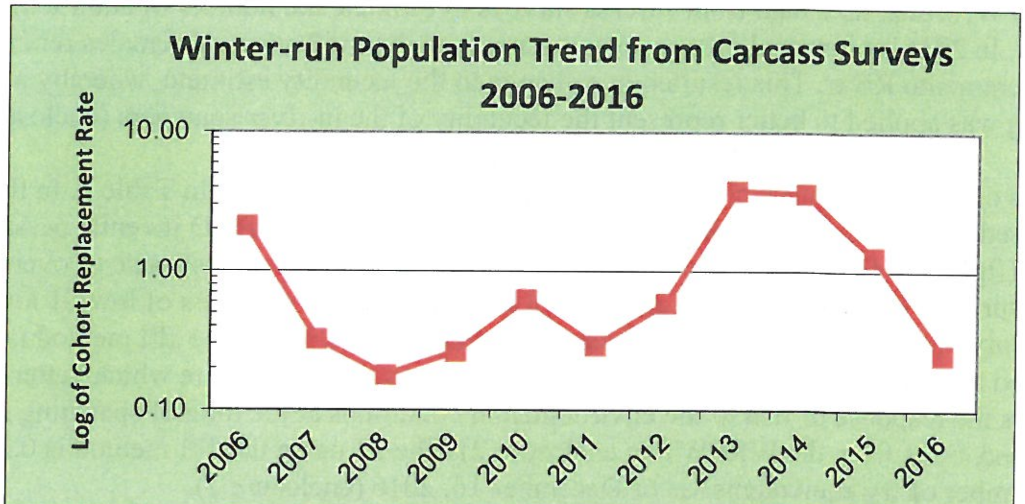

Figure 2. Cohort replacement rate for winter-run Chinook salmon 2006–2016 (CDFW 2016 and enclosure 1).

The JPE for BY 2016 incorporates the recommendations of the Independent Review Panel (IRP) [Delta Science Program (DSP) 2014] and advice from the WRPWT (enclosure 2). Based on these latest recommendations, NMFS is providing four methods of calculating the JPE for BY 2016, as follows:

1. NMFS spreadsheet
2. Cramer Fish Sciences (CFS) model: a systems dynamics computer simulation model that includes Monte Carlo stochastic simulations (CFS 2010)

3. Juvenile Production Index (JPI): estimated juvenile passage at Red Bluff Diversion Dam (RBDD) based on rotary screw trap (RST) monitoring
4. Historical Analysis: a comparison of monitoring data from RBDD to Sacramento

Table 1. Summary of JPE model runs. Adult escapement from enclosure 1.

JPE Method	Adult Escapement	Estimate of Viable Eggs	Survival to RBDD (S1)	Juveniles passing RBDD	Survival to Delta (S2)	Juveniles to Delta (JPE)
NMFS[1]	1,409	2,551,532	0.23	586,852	0.46	158,926
CFS model[2]	1,409	2,551,532	0.21	535,822	0.53	333,944
JPI[3]	1,409	2,551,532	0.24	613,675	0.46	166,189
Historical[4]	1,409	2,551,532	0.24	613,675	0.29	103,552

[1] NMFS spreadsheet model same as methodology in 2015, S1 is based on 15-year average 2002–2016. See enclosure 3.
[2] CFS winter-run production model at the 95% confidence interval (CI) level, using 2009 Dry Year flows at Freeport and temperature data at Bend Bridge. S1 is an approximate value, varies daily depending on exponential relationship with observed water temperatures (CFS 2010).
[3] Juvenile Production Index = the estimated number of fry equivalents based on passage at RBDD as of December 16, 2016, at the 90% CI level (Enclosure 2).
[4] S1 is the BY2016 survival from the JPI method, and S2 was calculated based on historical data comparison used to estimate S2 from RBDD and Sacramento Trawl data for BY2002–2013. BY 2012 was excluded.

Each of the methods used to calculate the JPE begins with the same adult escapement estimate from CDFW, which uses data from carcass surveys to estimate the number of adult female spawners. In 2016, an unusually larger than average number of 2-year old females returned to the upper Sacramento River. This resulted in a change to the fecundity estimate, whereby a weighting was applied to better represent the fecundity of the in-river spawners (enclosure 2).

Estimates of egg-to-fry survival rate (S1) vary among the methods used in Table 1. In the past, NMFS used the average S1 obtained from the carcass surveys and RBDD juvenile passage estimate (figure 3). However, use of an average can considerably underestimate or overestimate juvenile survival (*e.g.*, 0.49 in 2011 and 0.04 in 2015, respectively). Years of low S1 lower the average survival and may not represent actual conditions in the river. The JPI method is considered a more accurate estimate of S1 because it is an annual estimate which better represents the response of fish to the environmental conditions at the time of spawning (see recommendations from the WRPWT in enclosure 2). The S1 using the JPI method is 0.24 based on the number of fry equivalents[3] as of December 16, 2016 (enclosure 2).

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[3] Through December 16, 2016, estimated passage past Red Bluff Diversion Dam was 613,675 juvenile winter-run (http://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2015/BiWeekly20151217-20151231.pdf). This resulted in an estimated 24% survival, or conversely, 76% mortality of eggs and fry. Juvenile winter-run production was standardized by estimating a fry-equivalent JPI for among-year comparisons. The number of presmolts/smolts (≥ 46 mm FL) is multiplied by 1.7 to determine the fry-equivalents. See http://www.fws.gov/redbluff/MSJM%20Reports/RST/Brood%20Year%202013%20Juvenile%20Chinook%20Indices.pdf for further discussion.

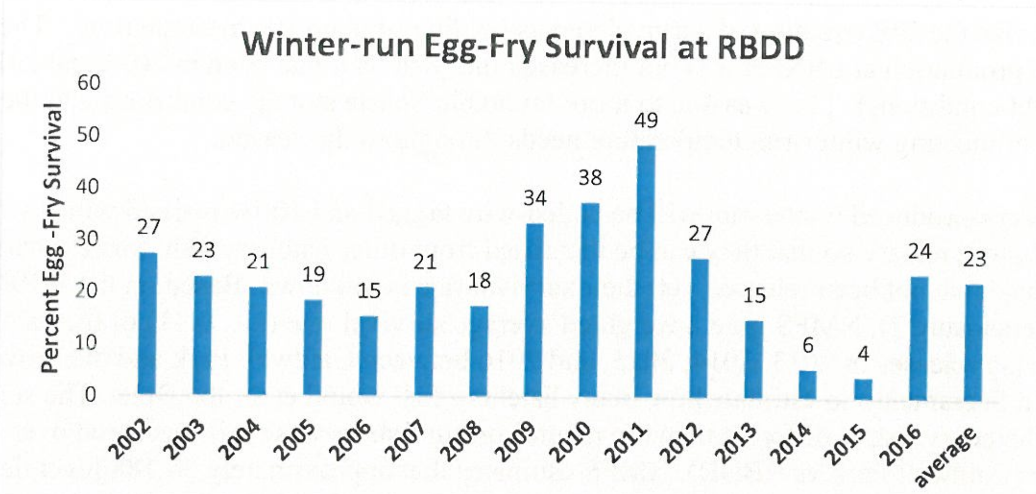

Figure 3. Winter-run egg-to-fry survival (S1) estimated at Red Bluff Diversion Dam 2002–2016 (Poytress *et al.* 2014, Poytress 2016, and Enclosure 2 for years 2015 and 2016)

The survival of juvenile winter-run to the Delta (S2) is based on assumed environmental conditions (*e.g.,* temperature, flows, and turbidity) in the Sacramento River. However, actual environmental conditions, which may occur after the JPE is calculated, may be different than those assumed in the calculation of the JPE. This year, based on recommendations from the WRPWT, smolt survival (S2) to the Delta (0.46) was calculated based on a weighted average of acoustically-tagged hatchery winter-run releases in 2013, 2014, 2015, and 2016 (enclosure 2) from RBDD to the Tower Bridge (at Sacramento). NMFS considers the Tower Bridge as the point of Delta entry. The S2 survival rate from acoustic tags was used in the NMFS spreadsheet and JPI methods. In addition, pursuant to the DSP (2014) recommendation to include a historical analysis, NMFS included in Table 1 an estimate of S2 survival based on a comparison of the historical monitoring data from 2002–2013 (average 0.286, range 0.04–0.67). The historical method utilizes data from the RBDD RST and the Sacramento Trawl to estimate S2 survival.

Method Selection and JPE Calculation

After reviewing the recommendations from the WRPWT technical team (enclosure 2), NMFS chose the JPI method to calculate the BY 2016 natural-origin winter-run JPE, since it more closely represented the actual hydrologic conditions experienced by BY 2016 (*i.e.*, May–December). Using the JPI method, and based upon, the WRPWT recommendation to use the JPI method, NMFS estimates a JPE of **166,189 natural-origin juvenile winter-run entering the Delta during WY 2017** (Table 1, enclosure 2). Winter-run juveniles are expected to emigrate into the Delta from November 2016 through April 2017, based upon CDFW historical monitoring data at Knights Landing rotary screw traps.

Approximately 500 juvenile winter-run propagated at LSNFH will be retained for the captive breeding program. In early February 2017, approximately 141,922 winter-run juveniles propagated at LSNFH will be released into the upper Sacramento River near Redding (Caldwell Park). This year, 570 of the hatchery production release will be acoustically tagged (JSAT) to monitor their survival and movement downstream. Of these, 200 may be released up to 30 days prior to the production release. The objective of the early tag release is to use this information to parameterize the JPE equation of survival versus holding time upstream in the river. The hatchery production at LSNFH was not increased this year as it had been in 2014 and 2015 (due to drought conditions). This was due to more favorable Shasta storage conditions and the forecast of meeting winter-run temperature needs throughout the season.

All hatchery-produced winter-run will be coded-wire tagged and 100% marked with an adipose fin clip before release so that they can be identified from other hatchery fish. Since the hatchery winter-run have not been released yet, their survival rate is unknown. Based on the WRPWT advice (enclosure 2), NMFS used a weighted average survival rate (*i.e.,* 0.41) of the hatchery acoustic tag releases in 2013, 2014, 2015, and 2016 between Caldwell Park and the Tower Bridge in Sacramento to estimate how many hatchery fish would enter the Delta. The survival rate for hatchery fish is different than the natural-origin fish because it is measured over a longer distance (Caldwell Park vs RBDD). NMFS estimates that approximately **58,188** juveniles from LSNFH will survive to enter the Delta during WY 2017 (enclosure 3).

The authorized incidental take limit for the combined CVP/SWP Delta pumping facilities includes both the natural (wild) and hatchery-produced juvenile winter-run, as both are necessary components of the population for survival and recovery of the species. The authorized incidental take for naturally-produced winter-run has been established in the CVP/SWP operations Opinion as 2 percent of the JPE to allow for errors in fish identification due to use of the length-at-date criteria to determine salmon race (*i.e.*, differentiating from fall-run, late-fall run, and spring-run Chinook salmon). This year, as in 2015, genetic race identification will be used. The use of genetic data to determine race of juvenile Chinook salmon observed at the CVP/SWP Delta pumping facilities eliminates the uncertainty that was included in previous annual incidental take limits for winter-run. Therefore, the authorized level of incidental take (*i.e.*, reported as loss at the Delta fish facilities) under the ESA for the combined CVP/SWP Delta pumping facilities from October 1, 2016, through June 30, 2017, is set at 1 percent or **1,662 natural (non-clipped)** winter-run. In addition, the incidental take for hatchery winter-run is set at 1 percent of the LSNFH release, or **582 hatchery-produced (clipped)** winter-run. If the incidental take for natural production (non-clipped) exceeds 0.5 percent of the JPE entering the Delta (*i.e.*, 831), or 0.5 percent of the hatchery (clipped) production (*i.e.*, 291), Reclamation and DWR must immediately convene the Water Operations Management Team (WOMT) to consider actions to minimize incidental take, pursuant to the CVP/SWP operations Opinion.

As was the case for BY 2015, the JPE is low enough that the fish-density based triggers used for Old and Middle River flow management Reasonable and Prudent Alternative Action IV.2.3 would be below the minimums established in the CVP/SWP operations Opinion. NMFS allows for flexibility in water operations by using the minimum (*i.e.,* loss density of 2.5 older juvenile Chinook salmon per thousand acre-feet of water exported) for the first stage trigger rather than a lower trigger based on the BY 2016 JPE (*i.e.*, 1.1 older juvenile Chinook salmon per thousand acre-feet of water exported). This minimum loss density will allow for more water to be exported before a loss density trigger is exceeded in WY 2017.

The initial identification of naturally-produced (non-clipped) winter-run at the CVP/SWP Delta fish facilities shall be based on the length-at-date criteria for the Delta. As additional information becomes available through genetic analysis of tissue samples and other fisheries monitoring programs (*e.g.*, continued acoustical tag studies) in the Central Valley, estimates of the incidental take at the Delta fish facilities may be adjusted, if deemed scientifically sound by NMFS. NMFS will continue to monitor daily fish salvage and loss, and loss densities of winter-run and other ESA-listed species at the Delta fish salvage facilities, through participation in the Delta Operations for Salmonids and Sturgeon technical team, WOMT, Drought Contingency Planning, California Water meetings, and Fish Agency Coordination.

NMFS acknowledges that additional research using acoustically-tagged winter-run (both hatchery and wild) is necessary to provide a more robust estimate of in-reach survival of winter-run in the Sacramento River and would also provide direct calculation of survival, thereby greatly improving the accuracy of the JPE. We recommend that funding be continued for acoustic tag studies on winter-run in 2017/2018 to provide data on survival rates over a range of hydrologic conditions. The DSP (2014) recommended committing resources to developing improved estimates of juvenile winter-run survival below RBDD. NMFS, as part of the "Species in the Spotlight" 2016 initiative, has funded the NMFS-Southwest Fisheries Science Center to develop a new JPE model. The new model should improve the accuracy of the JPE and will be ready for testing in 2017.

We look forward to continuing to work with Reclamation and the other State and Federal agencies to manage water resources in WY 2017 in a way that supports both water supply and fish and wildlife resources.

If you have any questions regarding this correspondence, or if NMFS can provide further assistance, please contact Mr. Bruce Oppenheim at (916) 930-3603, or via email at bruce.oppenheim@noaa.gov.

Sincerely,

Maria Rea

Maria Rea
Assistant Regional Administrator
California Central Valley Office

Enclosures:
1. CDFW updated brood year 2016 winter-run Chinook salmon escapement letter to NMFS, dated December 23, 2016
2. Winter-Run Project Work Team letter to NMFS, dated January 4, 2017
3. NMFS winter-run JPE based on the 2016 spawning escapement, spreadsheet

cc: Copy to file: ARN 151422SWR2006SA00268

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Doug Killam, CDFW, 2440 Main St., Rm. 41, Red Bluff, CA 96080
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Tom Patton, Reclamation, 3310 El Camino Ave, Sacramento, CA 95821-9000

References cited:

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Cramer Fish Sciences (CFS) 2010. A revised Sacramento River Winter Chinook Juvenile Production Model. Prepared for NOAA Fisheries. Cramer Fish Sciences, Auburn, CA. 30 pages.

Delta Science Program (DSP). 2014. Letter transmitting Independent Review Panel (IRP) Report for the 2014 Long-term Operations Biological Opinions (LOBO) Annual Science Review. A report to the Delta Science Program of the Delta Stewardship Council. December 2014. 47 pages.

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Poytress, W. R. 2016. Brood-year 2014 winter Chinook juvenile production indices with comparisons to juvenile production estimates derived from adult escapement. Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Sacramento, CA.

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CHARLTON H. BONHAM, Director

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December 23, 2016

Mr. Barry Thom
Regional Administrator, West Coast Region
National Marine Fisheries Service
7600 Sand Point Way Northeast
Seattle, WA 98115

Dear Mr. Thom:

***Updated Revised* Winter-run Chinook Salmon Escapement Estimates for 2016**

The Winter Run Chinook Salmon Escapement Estimate has been updated and revised below. The estimates have increased by 1 fish. The California Department of Fish and Wildlife (Department) has developed Sacramento River winter-run Chinook Salmon escapement estimates for 2016. These estimates were developed from data collected in the Upper Sacramento River Winter-run Chinook Salmon Escapement Survey (carcass survey) by Department and U.S. Fish and Wildlife Service (USFWS) personnel.

Escapement estimates based on the application of the Cormack-Jolly-Seber (CJS) mark-recapture population model to the carcass survey data for 2016 are shown below:

Estimated Total In-river Escapement (hatchery and natural origin)	**1,409**
Estimated In-river Escapement (hatchery origin)	**357**
Estimated Number of In-river Adult Females (hatchery and natural origin)	**658**

These estimates include naturally spawning winter-run Chinook Salmon (winter-run) in the upper Sacramento River. In addition, 137 winter-run were collected at the Keswick trap site upstream from RBDD for spawning at Livingston Stone National Fish Hatchery (LSNFH). These fish are not included in the above estimate of naturally spawning winter-run. The total winter-run spawning escapement estimate in 2016, including in-river spawners and fish collected for hatchery broodstock, is **1,546** fish. The **90%** confidence interval on this total estimate is from **329 to 2,763** fish.

This year, the escapement estimate was again calculated from the carcass survey data using a CJS model. The CJS model has been used from 2012 to present. From 2003-2011, the escapement estimate had been based on application of the Jolly-Seber model. In 2012, based on the recommendations of the *Central Valley Chinook Salmon In-River Escapement Monitoring Plan*, the winter-run carcass survey used field and analysis methods consistent with application of the CJS model. In simulation studies performed in the development of the Monitoring Plan, the CJS model was shown to more accurately estimate escapement based on mark-recapture data than any other available model. Due to its similarity to the Jolly-Seber model previously used to estimate winter-run escapement, we consider the data from 2012- 2016 to be directly comparable for trend analysis with escapement estimates from 2003 through 2011. The CJS model allows the calculation of confidence intervals; we began reporting confidence intervals on our total estimate for the first time in 2012 and continue doing so this year. The total escapement number above is the winter-run total estimate modeled to date and is a final number subject to revision. This estimate is subject to revision if additional data becomes available after the date of this letter. The additional data would then be used in the CJS model to recalculate the final escapement number. The most up to date modelled estimate calculation can be found in the GrandTab spreadsheet which is updated periodically after this letter is sent in the event that new information is received (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381&inline=1).

In 2016 the Fisheries Agency's recognized that continuing poor survival conditions from the ongoing drought were resulting in low returns of natural origin fish to the hatchery. This was anticipated from conditions the 2013 juvenile brood year experienced. In order to meet hatchery supplementation goals a small number of hatchery origin fish were actively collected to augment the low numbers of natural origin broodstock available. Low numbers of 3-year old females available resulted in the need to include 2-year old females into the hatchery production. A large portion (62%) of the female broodstock was hatchery origin 2-year old females. In general two year old fish produce fewer eggs resulting in a smaller number of juvenile hatchery origin fish produced in 2016 compared to other more typical years.

We look forward to further discussion and collaboration with NOAA Fisheries staff regarding the application of this information. Inquiries regarding the methodology and development of the estimates in this letter should be directed to Mr. Douglas Killam, Doug.Killam@wildlife.ca.gov or Mr. Daniel Kratville, Daniel.Kratville@wildlife.ca.gov and at the address and phone number above.

Sincerely,

Kevin Shaffer, Branch Chief

cc: Ms. Maria Rea, Sacramento Area Supervisor
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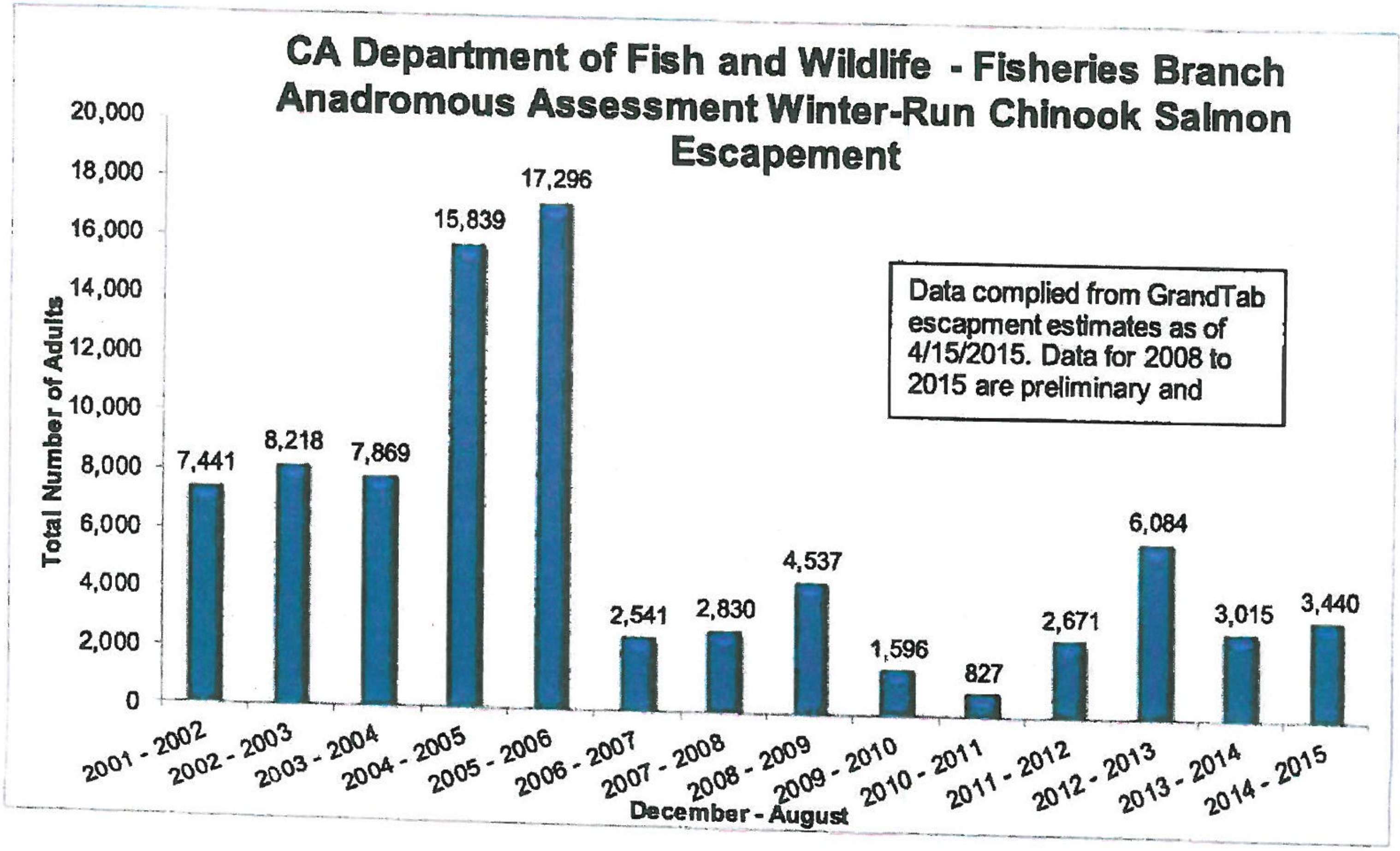
CA Department of Fish and Wildlife - Fisheries Branch
Anadromous Assessment Winter-Run Chinook Salmon
Escapement
Total Number of Adults
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
7,441
8,218
7,869
15,839
17,296
2,541
2,830
4,537
1,596
827
2,671
6,084
3,015
3,440
2001 - 2002
2002 - 2003
2003 - 2004
2004 - 2005
2005 - 2006
2006 - 2007
2007 - 2008
2008 - 2009
2009 - 2010
2010 - 2011
2011 - 2012
2012 - 2013
2013 - 2014
2014 - 2015
December - August
Data complied from GrandTab escapment estimates as of 4/15/2015. Data for 2008 to 2015 are preliminary and

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NAT'L MARINE FISHERIES SVS
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January 4, 2017

Mr. Garwin Yip
National Marine Fisheries Service
650 Capital Mall, Suite 5-100
Sacramento, CA 95814

Dear Mr. Yip:

Three years ago, the Interagency Ecological Program (IEP)'s Winter Run Project Work Team (WRPWT) recommended that the NOAA Fisheries Juvenile Production Estimate (JPE) be revisited annually and updated as needed with any new or improved information. A sub-team of the WRPWT met five times in 2016 to review the factors used to calculate the JPE. The JPE is used for estimating the incidental take limit of winter-run Chinook Salmon in the Delta at the State Water Project (SWP) and Central Valley Project (CVP). The sub-team also discussed priority monitoring and research that would improve future JPE estimates and provide better information for managing water project operations.

JPE Recommendations:

The sub-team identified four factors in the JPE similar to last year that they would advise continuing or updating for the 2016 broodyear:

1) estimated number of fry passing Red Bluff Diversion Dam (RBDD)

2) survival rate of fry to smolts

3) survival rate of smolts from RBDD to Delta entry (defined as Sacramento, at the I80/I50 Bridge)

4) estimated survival rate of the winter-run hatchery fish to be released in January or February of 2017

In 2016, California Department of Fish and Wildlife (CDFW) estimated 1,546 winter-run adults returned to the upper river, and of these, 1,409 were counted as in-river escapement in the JPE (Table 1). Of those, 46.7 percent were female, for a total in-river adult female escapement estimate of 658 (Table 1). Pre-spawning adult mortality was estimated at .008 (Table 1) resulting in 653 adult female winter-run estimated to have spawned. A change to fecundity in 2016 was calculated based on a weighted average of fecundity from 2-yr old and 3-yr old fish from Livingston-Stone National Fish Hatchery (LSNFH) broodstock (see Attachment A). This weighted estimate of fecundity (3907.4) resulted in an estimate of 2,551,585 total eggs laid in-river in 2016 (Table 1).

While we believe the eggs and alevins survived better than the past two years, the sub-team's first recommendation is to use the Juvenile Production Index (JPI) in the JPE for 2016-2017 which is based on fry equivalents at RBDD, as was used in 2014-2015 and 2015-2016 (Figure 1). The JPI seasonal estimate as of December 16, 2016 was 613,675 (B. Poytress, USFWS, personal communication; Table 1). The value through week 50 (December 16) accounts for approximately 96% of annual winter-run passage at RBDD based on data collected from 2002 to 2014 and includes an interpolation of the remaining 4% in 2016-2017 (590,969 / 0.963 = 613,675). We believe the JPI is a better estimate of fry survival to RBDD, than the average long-term egg to fry survival rate used previously in the JPE, because it is an annual empirical estimate and better represents the response of fish to annual environmental conditions during spawning, egg incubation and outmigration. With this estimate of fry production at RBDD, the estimated egg to fry survival is calculated to be .24 (Table 1).

The second recommendation of the sub-team is the continued inclusion of a factor to account for survival between the peak of fry catch at Red Bluff (generally in October) and the smolt life-stage at Red Bluff for the naturally produced winter-run. There can be as many as four months during the fry to smolt transition and a survival estimate is needed during this time period. The available survival estimates between RBDD and Delta entry are based on releases of acoustically telemetered (AT) smolts, which have a higher survival rate than fry due to their larger size and faster migration rates. These fish are released in the spring depending on conditions. A survival rate of 0.59, based on fall-run salmon survival from fry to smolt has been used for winter-run fry to smolt survival since 1993. This value is based on previous studies (Hallock, undated), and confirmed through a literature review in 1995 (B. Poytress, USFWS, personal communication). Without this survival factor, survival from fry to smolts is assumed to be 100%, which is unrealistic. While we have reservations about the accuracy of this term (0.59; Table 1 and Figure 1), we believe it should continue to be used, until a better estimate of fry to smolt survival is available. To address this critical uncertainty we suggest that additional studies be conducted in the future to better estimate fry to smolt survival (see monitoring recommendations below).

The third recommendation of the sub-team is related to the smolt survival term for estimating survival from RBDD (*i.e.*, Salt Creek) to the Delta (*i.e.*, Sacramento; at the I-80/I50 Bridge) for naturally produced winter-run smolts. We recommend using results from acoustic tagging of LSNFH smolts in 2013, 2014, 2015, and 2016 for this term. There were two release groups in 2015 and 2016. Based on recommendations from Ken Newman (statistician from the U.S. Fish and Wildlife Service, Lodi Office), we first pooled individual estimates in 2015 and again for 2016, prior to estimating the weighted average of annual survival from RBDD to the Delta of 0.459 (A. Ammann, NMFS, personal communication; Attachment B). All hatchery releases were made at Caldwell Park, except in 2016 where they were made at Bonnyview Boat ramp, approximately six miles further downstream. The survival estimate used for naturally produced winter-run, is the acoustic tagged hatchery fish survivals from RBDD to the Delta, from the confluence of Salt Creek to the I80/I50 Bridge in Sacramento.

The fourth recommendation from the sub-team is updating the term for estimating survival of hatchery winter-run to the Delta (Table 1 and Figure 1). Last year, this term was the average of the 2013, 2014 and the two estimates from 2015 of winter-run survival to the Delta (0.37). This year the sub-team recommends that the weighted average of the four estimates of annual survival be used, which results in an estimate of 0.410. This is the estimate obtained when pooling the 2015 and 2016 data prior to averaging it with results from 2013 and 2014 (Attachment B). The reason these survival rates are different than those used for the wild winter-run (used in the previous paragraph) is because we want an estimate of survival for the hatchery fish which are to be released at Caldwell Park, whereas for the wild winter-run we only want an estimate that is from RBDD to I80/I50 Bridge to apply to the JPI fry equivalents at RBDD.

Monitoring Recommendations:

One of the models we have been developing to support the JPE is associated with the migration time of winter-run acoustic tagged hatchery fish to the Delta and their survival to the Delta. In using the last four years of data (six data points) from the acoustic tag releases of hatchery fish we have found that survival to the Delta appears to be related to migration time to the Delta. The lowest survival was in 2013, when the migration time to the Delta was the greatest at 40 days and the highest survival was for the second release in 2015 when the migration time to the Delta was only 10 days (Figure 2). To be able to apply this model to smaller-sized winter-run, we are recommending that hatchery winter-run be acoustically tagged and released at a smaller size (which is possible now due to smaller tag sizes), earlier in the season (*e.g.*, December, or early January), to inform our model for future application to smaller winter-run observed at RBDD. We are unable to acoustically tag the earliest/smallest migrating winter-run fish, even with the smallest acoustic tags available to date.

This recommendation of acoustic tagging a small number of the hatchery winter-run and releasing them earlier in the season was supported by the sub-team as a way to estimate a portion of the fry-to-smolt survival from RBDD to the Delta for the JPE and is likely to be implemented in 2017. While most members of the sub-team thought that continuing to acoustically tag a portion of the hatchery winter-run over the next 10 years is important, although not funded after 2017, there is also support to develop a wild winter-run tagging proposal. While this is proposed for 2016-2017 there is not enough wild winter-run at a taggable size to complete this task.

A recommendation from the IEP Salmon Assessment and Indicators by Life-stage (SAIL) is to develop run-specific abundance estimates entering and exiting the Delta (Johnson et al. *in review*). If an abundance estimate of winter-run entering and exiting the Delta could be achieved, this would provide additional empirical data necessary to test the accuracy of the current calculations for estimating the incidental take limit of winter-run Chinook Salmon in the Delta at the SWP and CVP.

In response to this recommendation, a proposal has been developed to the IEP to improve trawl efficiency estimates for the existing Sacramento and Chipps Island trawls using paired coded wire tagged and acoustically tagged juvenile salmon with genetic sampling in order to generate winter-run abundance estimates. As part of this proposal, an analysis of previously collected genetic samples at Sacramento could provide a broader time series (2009-2011) to compare with the estimated JPE and estimated loss at the salvage facilities. IEP is working to implement this recommendation in 2017 and will continue to seek input from the winter-run PWT as well as the broader scientific community at the IEP workshop in March 2017 considering some of the unique technical challenges anticipated with this proposal.

Other monitoring or research that was discussed by the sub-team, that we continue to support include:

1) placement of acoustic receivers in the central and south Delta to understand movement of tagged winter-run;

2) placement of real time monitoring receivers to provide accurate proportions of acoustic tagged hatchery winter-run at various locations as they move into and through the Delta;

3) funding winter-run otolith and synthesis work to learn where the successful adult survivors reared and how long they spend in different habitats as juveniles and;

4) increasing effort at Sacramento and Chipps Island trawls to better estimate winter-run abundance.

Most of these elements are being funded in 2017, with the exception of number 3, funding additional winter-run otolith work, but it has been proposed to the Delta Stewardship Council as a Delta Science postdoctoral fellowship opportunity. We also generally support monitoring recommendations in the IEP SAIL report (Johnson et al. *in review*).

While we acknowledge that there will still be uncertainty in the JPE estimate, even if these recommendations are incorporated, we believe it to be the best information available from which to derive a JPE. To reduce the uncertainty in the JPE in future years, we have suggested some additional monitoring and analyses to be conducted in 2017.

To better manage exports for improving juvenile winter-run survival in the Delta, a suggestion was made last year, during sub-team discussions, to estimate patterns of entrainment using genetic and coded-wire tag information for exporting water at the SWP and CVP in ways that entrainment loss estimation could be targeted to be below required limits. We are continuing to evaluate such an analytical method, but as of yet, have not determined it would be better than using the JPE methodology.

In summary, we hope these additional analyses and technical advice from the sub-team of the IEP's Winter Run Project Work Team will help improve the JPE and the incidental take limits for 2016-2017. Drought conditions in the past two years have likely resulted in significant impacts to the wild winter-run population. The Winter Run PWT continues to try to increase the accuracy of the JPE for the SWP and CVP water projects in water year 2017, for minimization of incidental take impacts to the winter-run Chinook Salmon population.

Sincerely,

Daniel Kratville
Winter Run PWT Chairperson

cc: Ms. Maria Rea, Sacramento Area Supervisor
National Marine Fisheries Service
SWR Sacramento Area Office
650 Capitol Mall, Suite 8-300
Sacramento CA, 95814

ec: Kevin Shaffer, Chief
Fisheries Branch
Kevin.Shaffer@wildlife.ca.gov

Winter-Run Project Work Team

Table 1: Factors in the Juvenile Production Estimate and the resulting estimates for 2016-2017, using the Winter-Run PWT approach. Hatchery components in red text.

	Factors	2016-2017 Result using suggested methodology
Total In-river escapement [1]		1,409
Adult female estimate [2]		658
Pre-spawn mortality [3]		0.8%
Average Fecundity [4]		3907.4
Total Viable Eggs		2,551,585
In redd loss and fry loss upstream of RBDD due to temperature and other factors [5]	0.76	
Estimated survival: egg to fry (at RBDD) [6]	0.24	
Estimate of fry production at RBDD [7]		613,675
fry survival from October (peak at RBDD in most years) to February for smolt at RBDD [8]	0.59	362,068
Estimated smolt survival – RBDD to Delta [9]	0.459	166,189
Total natural production entering the Delta		166,189
hatchery release [10]		139,500
Total hatchery production entering the Delta [11]	0.41	57,195
Level of concern for naturally produced fish (1%)		1,662
Level of concern for hatchery fish (0.5%)		286
Incidental Take limit for Natural Production (2%)		3,324
Incidental Take limit for hatchery production (1%)		572

Footnotes:

1/ Total in-river escapement from CDFW Cormack-Jolly Seber (CJS) model includes natural and hatchery origin, but not hatchery fish retained for brood stock at Livingston Stone National Fish Hatchery.

2/ The number of adult females is derived from carcass survey and then the number of males is derived using sex ratio at Keswick trap

3/ Pre-Spawn mortality was estimated from carcass surveys of females (CDFW)

4/ Average # eggs/female from weighted estimate based on two year and three old fish spawned at Livingston Stone Hatchery and in the carcass survey(Attachment A).

5/ Estimated mortality between egg and fry upstream of Red Bluff based on numbers of fry equivalents at RBDD divided by total number of eggs laid

6/ Egg to fry survival based on 1 minus the estimated loss on previous line

7/ Number of fry equivalents estimated on December 16, 2016 at RBDD – JPI – Bill Poytress, (USFWS), personal communication

8/ Estimate of fry to smolt survival based on fall run at Tehama Colusa Spawning Channel (Hallock undated)

9/ Average weighted survival of acoustically tagged winter-run in 2013, 2014 and 2015 (2 values in 2015) between RBDD and I80 Tower Bridge in Sacramento – A. Ammann, NMFS, personal communication. Survival is estimated from the Salt Creek receiver site, located 3 miles downstream of RBDD, to estimate survival from RBDD for acoustic tag studies.

10/ LSNFH estimated release as of 12/16/16 (100% tagged and adipose clipped). 11/ Weighted average of acoustically tagged winter-run survival in 2013, 2014 and 2015 and 2016 (2 values in 2015 and 2016) between release location and I80/I50 Bridge in Sacramento, (Pat Brandes, USFWS and A. Ammann, NMFS, personal comm, Attachment B).

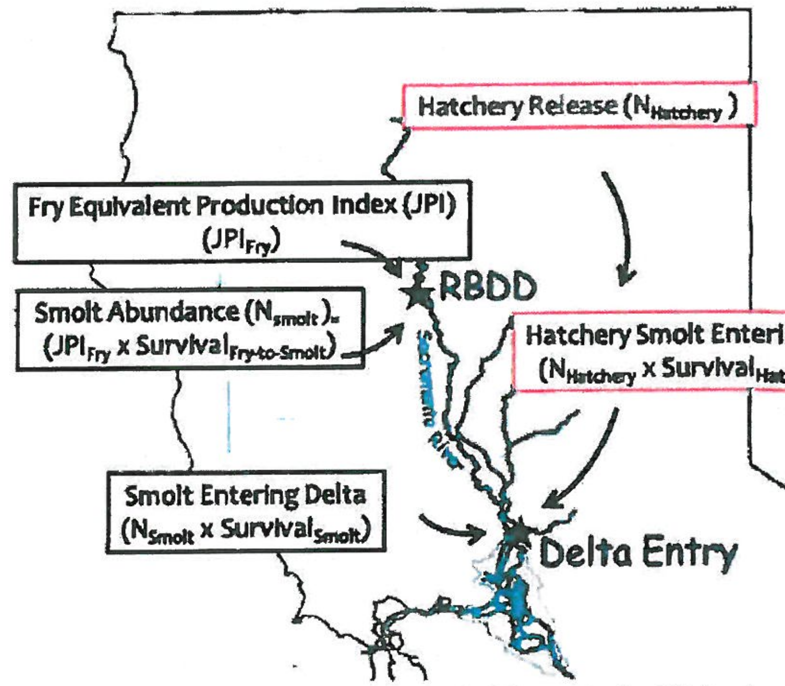


Figure 1: Location and formula's recommended for use in the JPE for the wild (black boxes) and hatchery (red boxes) components of the winter run population estimated in 2015-2016.

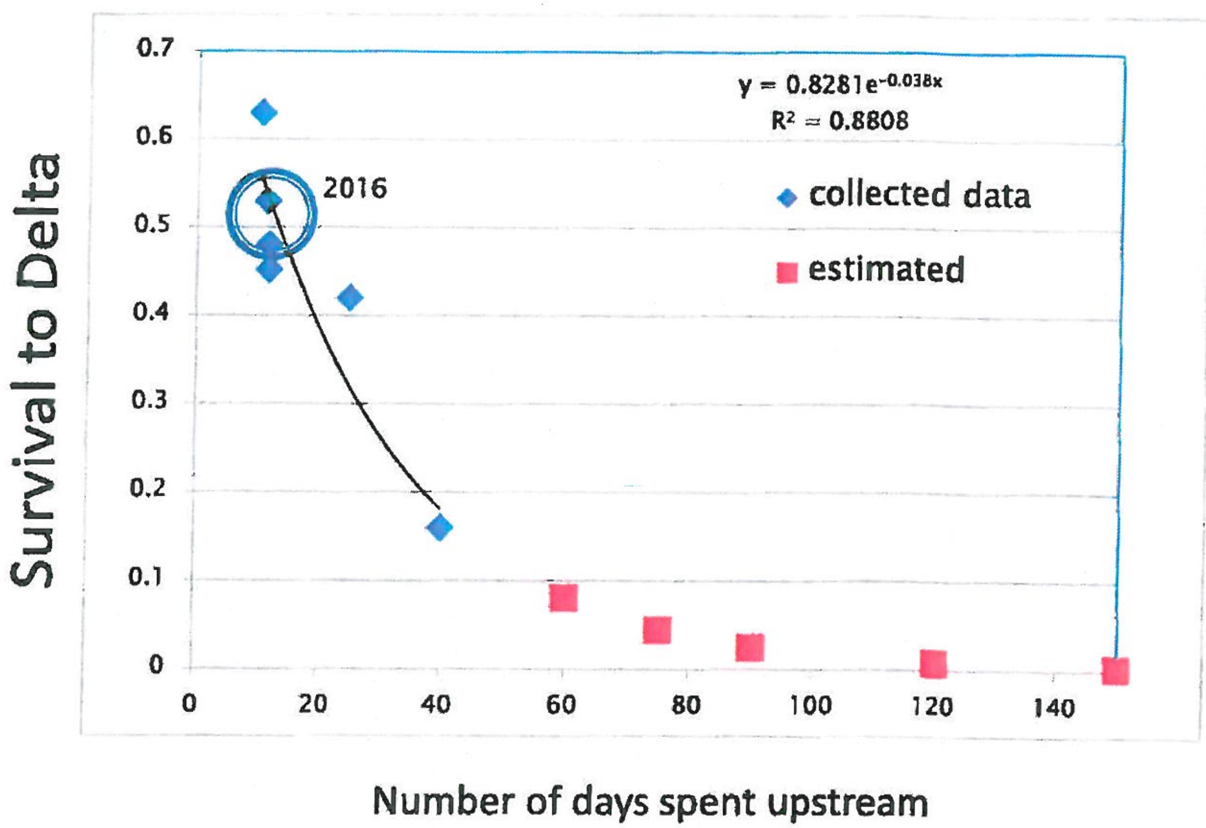


Figure 2: Relationship between the number of days spent upstream and survival to the Delta. Collected data has only been for 40 days spent upstream or less (diamonds). Survival data for greater than 40 days (squares) was estimated based on the relationship from actual data.

Attachment A

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Red Bluff Fish and Wildlife Office
10950 Tyler Road, Red Bluff, CA 96080
Phone: (530) 527-3043; FAX (530) 529-0292

In reply refer to:

Memorandum

DEC 1 5

To: File

cc: Bill Poytress and Kevin Niemela, Program Managers, Red Bluff Fish and Wildlife Office

From: James G. Smith, Project Leader, Red Bluff Fish and Wildlife Office James G. Smith

Subject: Documentation of a change to the methodology of estimating winter-run Chinook egg-to-fry survival for brood-year 2016

An unusually and relatively large proportion of the female winter-run Chinook broodstock collected at the Keswick Dam Fish Trap in 2016 were age-2, in comparison to the lower proportion of age-2 fish observed in the natural spawning population. As a result of differing age compositions in the hatchery and natural spawning populations, the standard method of calculating juvenile winter-run Chinook egg-to-fry (ETF) survival rates using RBDD rotary trap fry-equivalent production estimates could produce a positively biased estimate of egg-to-fry survival. This memo documents changes to the methodology for calculating egg-to-fry survival for brood year 2016 juvenile winter-run Chinook, which are intended to correct for this apparent bias.

The standard methodology of estimating egg-to-fry survival of winter-run Chinook, which has been used since 1995 (Martin et al. 2001, Poytress et al. 2014, Poytress 2016), entails the use of average annual fecundity data from the Livingston Stone National Fish Hatchery (LSNFH; 2002-2015) multiplied by the number of natural spawning females, as estimated using the annual carcass survey. Annual fry-equivalent production values for winter-run Chinook (based on length-at-date criteria) are then divided by the product of the average fecundity and in-river female spawner estimates (Eq 1).

1. $$\hat{ETF}_w = \frac{J\hat{P}I_f}{S_f * (F_e)}$$

where,

ETF_w = estimated egg-to-fry survival (winter-run Chinook)
JPI_f= estimated fry-equivalent production
S_f= estimated female spawners
F_e = estimated in-river egg deposition

However, during September of 2016 fishery agency representatives from the IEP winter-run project work team met and agreed that the discrepancy of ages observed between winter-run Chinook that were used for hatchery broodstock and the natural spawning population would likely result in a positive bias of the estimated survival of juvenile winter-run Chinook. At the same meeting, it was determined that a more appropriate methodology for estimating the number of winter-run eggs deposited in the Sacramento River in 2016 would be to differentiate between the fecundity values of two different size classes of winter-run Chinook spawners (Attachment 1); generally fractionating the run into age-2 (i.e., "jill") and age-2+ (i.e., adult) length categories. A fork length break at 630 mm was determined to be an appropriate length to generally differentiate between jill and adult female winter-run Chinook in 2016. Fecundity estimates were then averaged separately for the two size classes of female spawners at LSNFH. Estimates of female winter-run Chinook spawning naturally were determined from length data resulting from the Upper Sacramento River winter-run Chinook carcass survey. The result is the application of two different egg counts for the two different size classes of females spawning naturally (Table 1). Two other methodologies were also considered and included in attachment 1.

Table 1. Average fecundity of female winter-run Chinook spawned at the LSNFH applied to two length categories from the winter-run Chinook carcass surveys in 2016.

Average Fecundity < 630mm (n=34)		3,140
Average Fecundity ≥ 630mm (n=19)		4,043
Estimated number naturally spawning females < 630mm		98
Estimated number naturally spawning females ≥ 630mm		555
Estimated egg deposition (in-river)	< 630mm	307,720
	≥ 630mm	2,243,865
	Total	**2,551,585**

For the 2016 winter-run Chinook ETF calculation, the above estimated value of **2,551,585** eggs in the river will be used as product of the two estimates of fecundity applied to two estimates of female spawners categorized by length. The 2016 RBDD fry-equivalent juvenile production index (JPI) will therefore be divided by the estimated egg deposition (in-river) value in Table 1 as follows (Eq 2):

2. $$\hat{ETF}_w = \frac{\hat{JPI}_f}{((S_j * F_j) + (S_a * F_a))}$$

where,
ETF_w = estimated egg-to-fry survival (winter-run Chinook)
JPI_f = estimated fry-equivalent production
S_j = estimated female spawners (<630 mm)
F_j = estimated in-river egg deposition (<630 mm)
S_a = estimated female spawners (≥630 mm)
F_a = estimated in-river egg deposition (≥630 mm)

Attachment 1. Comparison of three potential methods to estimate egg deposition by naturally spawning winter-run Chinook Salmon in the Sacramento River in 2016.

The NMFS-NOAA Fisheries uses a spreadsheet model as one method to estimate the number of winter-run Chinook juveniles entering the Delta. This method considers the estimated abundance of eggs deposited by female winter-run Chinook spawners and subtracts estimates of mortality through the stages of incubation, hatching, swim-up, early-rearing, and emigration to the Delta. Implicit in calculating this estimate is knowledge of the abundance of eggs deposited by natural spawning winter-run Chinook.

In the past, the number of eggs deposited in the river has been estimated by multiplying the estimated number of naturally spawning female winter-run Chinook from the Winter Chinook Carcass Survey times the average fecundity of winter-run Chinook spawned at the LSNFH. The validity of this methodology assumes that the fecundity of winter-run Chinook females spawned at the LSNFH portrays an accurate representation of winter Chinook spawning in the Sacramento River. This assumption is generally believed to be valid because LSNFH broodstock typically consist of only natural origin fish and, as such, they are generally considered a representative subset of the natural spawning population. However, protocols for selecting hatchery broodstock in 2016 differed from typical years; in an effort to maintain a high-level of production, it was necessary to dramatically increase the use of hatchery origin broodstock in 2016. Thus, the fecundity of LSNFH broodstock spawned in 2016 may not provide an accurate representation of winter-run Chinook spawning naturally. For example, female winter-run Chinook broodstock at the LSNFH differed in length and origin compared to winter Chinook carcasses recovered from natural spawning areas of the Sacramento River. Seventy percent (n=39) of the female winter Chinook spawned at the LSNFH were of hatchery origin, whereas, hatchery fish are estimated to comprise only 30% (n=465) of the natural spawning winter Chinook. Sixty-four percent (n=36) of the female broodstock at the LSNFH were less than 630mm whereas, in natural spawning areas, females less than 630mm are estimated to comprise only 15% of the winter-run Chinook spawners. Because a strong relationship exists between body length and fecundity (Figure 1), these discordances between LSNFH broodstock and natural spawning winter Chinook may affect the validity of the assumption that the fecundity observed at LSNFH is representative of the fecundity of natural spawners.

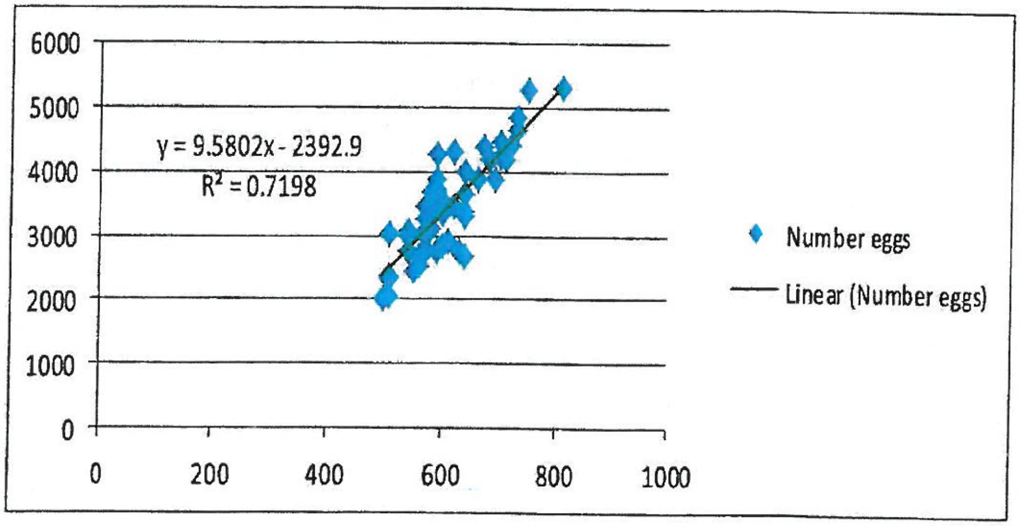
We evaluated three methodologies for estimating egg deposition through fecundity measures of natural spawning winter-run Chinook for comparison purposes. The three methodologies evaluated for estimating fecundity included the following: 1) the methodology used in most of the previous years, which consider the average fecundity of female winter-run Chinook spawned at LSNFH in the year of interest, 2) taking a 14-year average of the annual fecundity values gathered at LSNFH for the years 2002-2015 (Table 1), and 3) estimating fecundity for two size categories of female winter-run Chinook spawned at LSNFH, and then applying these two fecundity estimates to the appropriate fractions of natural spawning winter-run Chinook that fall within each size range.

The third methodology is equivalent to applying a weighted average of fecundity for two length categories of winter Chinook. The two length categories we used to categorize winter Chinook fecundity (small < 630mm; large ≥630mm) are based on the length delineation used by D. Killam (CDFW) to differentiate between age-2 and age-3 female winter Chinook observed on the 2016 carcass survey (Figure 1).

Table 1. Annual average number of eggs per winter-run Chinook female spawned at LSNFH between 2002 and 2015 with summary statistics below.

Year	Egg/Female
2002	4,820
2003	4,854
2004	5,200
2005	5,251
2006	5,382
2007	5,056
2008	5,424
2009	5,231
2010	5,161
2011	4,776
2012	4,364
2013	4,596
2014	5,191
2015	4,819
min	4,364
Ave	**5,009**
max	5,424
StDev	**310**

Figure 1. Linear regression of winter-run Chinook female spawner fork length and fecundity (number of eggs) in 2016 at Livingston Stone NFH.



By direct comparison, methods 1 and 3 result in the most similar estimates (Table 2). The method of applying separate estimates of fecundity for two different length categories of female winter-run Chinook yields an estimate of egg deposition that exceeds the estimate that considers an overall average of fecundity by 289,593 (12.8%). The method of using a historic average of 14 years of prior fecundity data results in a substantially greater number of eggs estimated to be deposited in the river at 1,008,885 (44.6%) and 719,292 (28.2%) when compared to methods 1 and 3, respectively.

Based upon observed differences in the characteristics of female winter Chinook broodstock at the LSNFH and natural spawning winter-run Chinook in the Sacramento River, we consider the length-based methodology to provide the most appropriate estimator of egg deposition for the 2016 spawning year. Although this change in methodology, we believe, results in values more reflective of in-river egg deposition, the overall difference between the Method 1 and 3 is rather small. Therefore, we believe that using this methodology in 2016 will not affect comparisons of annual survival between years.

Table 2. Numerical results of the three methods evaluated.

Method 1. Average fecundity of LSNFH spawners (2016).	
Average Annual Fecundity at LSNFH (n=53)	3,464
Estimated number of females spawning naturally (minus DK pre-spawn adult morts (n= 5)	653
Estimated egg deposition	**2,261,992**

Method 2. Historic annual average fecundity of LSNFH spawners (2002-2015).	
Average Annual Fecundity at LSNFH (n=14)	5,009
Estimated number of females spawning naturally (minus DK pre-spawn adult morts (n= 5)	653
Estimated egg deposition	**3,270,877**

Method 3. Average fecundity applied to two length categories of female winter-run Chinook spawned at LSNFH (2016).		
Average Fecundity <630 mm FL (n=34)		3,140
Average Fecundity >/=630 mm FL (n=19)		4,043
Estimated number of naturally spawning females <630 mm FL		98
Estimated number of naturally spawning females >/=630 mm FL (minus DK pre-spawn adult morts (n= 5)		555
Estimated egg deposition <630 mm FL		307,720
Estimated egg deposition >/=630 mm FL		2,243,865
	Total	**2,551,585**

Attachment B

Attachment B: Estimates of survival of hatchery winter run from acoustic tag fish for 2013-2016.
Request by Pat Brandes and Noble Hendrix for use in JPE.
Date Produced: 10/24/2016
From: Arnold Ammann NOAA Fisheries ERD Santa Cruz lab, data from JSATS acoustic tagging and

Year	Study	Run	release date	Number AT fish released in Redding	Number fish to SaltCk*
2016	LSNFH - Pooled	Winter-run	2/17, 2/18	570	538
2016	LSNFH - rel 1	Winter-run	2/17/2016 18:00	285	273
2016	LSNFH - rel 2	Winter-run	2/18/2016 18:30	285	265
2015	LSNFH - Pooled	Winter-run	2/4,2/6/2015	567	471
2015	LSNFH - rel 1	Winter-run	2/4/2015 17:30	249	230
2015	LSNFH - rel 2	Winter-run	2/6/2015 17:30	318	241
2014	LSNFH	Winter Run	2/10/2014 17:30	358	325
2013	LSNFH	Winter Run	2/7/2013 17:30	148	137

Note: SaltCk is 4.77 river km downstream of Red Bluff Diverson Dam
Note: sample of hatchery fish implanted with 0.42 to 0.30 gram JSATS transmitters. Size ranged fı
* total of all fish detect at or below SaltCk receiver location
** total of all fish detected at or below Sacramento I80/50 Bridge (or Tower Bridge) receiver loca

Weighted averages: calculated by Pat Brandes 12/5/16

	Salt Creek to I80/ var
2016	0.0005
2015	0.000529
2014	0.000729
2013	0.0010

tracking of hatchery winter-run out migration

Number fish to Sac I80/50 Bridge**	Cumulative CJS survival estimates with error calculated using Delta Method with RMark: SaltCk to Sac I80/50 Bridge				Cumulative CJS survival estimates with error calculated using Delta Method with RMark: Release to Sac I80/50 Bridge			
	Survival	**SE**	**LCI**	**UCI**	**Survival**	**SE**	**LCI**	**UCI**
288	0.535	0.022	0.493	0.577	0.505	0.021	0.464	0.546
137	0.502	0.030	0.443	0.561	0.481	0.030	0.426	0.539
151	0.570	0.030	0.509	0.628	0.530	0.030	0.472	0.587
269	0.571	0.023	0.526	0.615	0.474	0.021	0.434	0.516
105	0.457	0.033	0.393	0.521	0.422	0.031	0.362	0.484
164	0.680	0.030	0.619	0.736	0.516	0.028	0.461	0.570
135	0.415	0.027	0.363	0.470	0.374	0.026	0.326	0.426
22	0.161	0.031	0.108	0.232	0.149	0.029	0.100	0.215

rom 95-100mmFL.

X = w2013*s2013+w2014*s2014+

tion

wi= 1/var (i)/(1/var(2013)+

'50 bridge

1/var	w	s	+w*s"
2066.115702	0.324412	0.535	0.17356
1890.359168	0.296816	0.571	0.169482
1371.742112	0.215385	0.415	0.089385
1040.582726	0.163388	0.161	0.026305
6368.79971			0.458732 salt creek to I80/50 bridge

	var	1/var	w
2016	0.0004	2267.574	0.314788
2015	0.0004	2267.574	0.314788
2014	0.0007	1479.29	0.205357
2013	0.0008	1189.061	0.165067
		7203.498	

w2015*s2015+w2016*s2016

1/var(2014)+1/var(2015)+1/var(2016)

s	+w*s"	
0.505	0.158968	
0.474	0.149209	
0.374	0.076804	
0.149	0.024595	
	0.409576	Release to I80 bridge

NMFS - Southwest Region

WINTER RUN JPE ESTIMATOR PROGRAM

Enclosure 3

DATA ENTRY HERE	
Year Pair	Broodyear
2016/2017	2013
Carcasses observed	
297	
Females unspawned	
5.00	3/
CDFG Carcass Survey	
1,409	1/
Female Percent	
46.70%	2/
LSNFH Hatchery Release	
141,922	
Release Date	
02/05/17	

Version 1 1/13/2017

WINTER RUN CHINOOK SALMON 2017 Juvenile Production Estimate	Factors	Carcass Survey Estimate
Total in-river escapement - 1/		1,409
In-river adult females - 2/	0.467	658
Prespawn mortality - 3/	0.992	653
Average fecundity - 4/	3907.4	2,551,532
Egg loss due to temperature (old method)- 5/	0.000	
Total viable eggs		2,551,532
Egg to fry survival from JPI estimate at RBDD (S1) -6/	0.230	586,852
Fry to pre-smolt survival (Oct-Mar) - 7/	0.590	346,243
Survival to Delta (S2) - 8/ (RBDD to Tower Bridge at Sacramento)	0.459	158,926
Total Natural Production Entering Delta		158,926
Hatchery Release - 9/		141,922
Hatchery Production Entering Delta - 10/	0.410	58,188
Level of Concern for wild fish (0.5%)		795
Level of Concern for hatchery fish (0.5%)		291
Incidental Take Level for wild fish (1%)		1,589
Incidental Take level for Hatchery Production (1%)		582

Footnotes -

1/ Total in-river escapement, hatchery & natural origin, CDFW letter 12/07/16 (Not including 136 kept for broodstock)
2/ In-river females derrived from carcass survey. Males derived using sex ratio at Keswick trap.
3/ Pre-spawn mortality from 2016 carcass survey data (CDFW Table 1 Summary).
4/ fecundity calculated based on weighted average of 2-yr old +3-yr old females (USFWS Memo)
5/ No redds observed below the temperature compliance point at Clear Creek.
6/ Average egg-fry survival based on 15 years (2002-2016)
7/ fry-smolt survival from fall-run Chinook studies at Tehama-Colusa spawning channel (USFWS 1975-1980)
8/ Smolt survival based on weighted average of acoustic tag releases (2013-2016) RBDD to Sacramento (attach. B)
9/ LSNFH final count after tagging, Niemela pers.comm. 1/12/17 (100% ad-clipped & CWT).
10/ Hatchery survival based on weighted average of accoustic tags (2013-2016) Caldwell Park to Sacramento.